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we are perhaps warranted in concluding that the ancestral type of lepidopterous larvæ was provided with two pairs of thoracic spiracles.

GEOGRAPHICAL VARIATION IN NORTH AMERICAN BIRDS.*

BY J. A. ALLEN.

PROBABLY the birds of no equal area of the earth's surface are better known than those of North America north of Mexico, or of the whole continent southward even to the Isthmus of Panama. No museums in the world, probably, possess so large suites of specimens of single species as there are of North American birds in the Museum of the Smithsonian Institution and in the Museum of Comparative Zoology, nor from so many localities. In many instances single species are represented by hundreds of specimens collected at frequent intervals throughout their known range. Those contained in the Smithsonian Institution have been most carefully elaborated by Prof. Baird and others, whose reports upon them have justly acquired a world-wide reputation for their thoroughness and accuracy. Those in the Museum of Comparative Zoology have also been carefully studied.

Briefly, then, what are the facts and the general results that have followed the investigation of this exceptionally large amount of material? What are the allowable inferences, and what general principles have been apparently established? To answer these questions as briefly as may be is the object of the present remarks, — premising, however, that the formerly current opinions respecting the rank of a certain class of forms heretofore generally regarded as specific have been radically modified. Intergradation has been frequently traced between widely different forms, a gradual coalescence in scores of instances having been positively established, and rendered extremely probable in a large number of others.

In North America geographical variation exhibits two marked phases : — (1) a differentiation with differences of latitude and elevation, and (2) differentiation with differences of longitude ; which, for convenience, may be termed respectively latitudinal

*From the Proc. Bost. Soc. Nat. Hist., vol. xv, p. 212.

and longitudinal variation.* In respect to both, differentiation occurs in different degrees in different groups, in accordance with their general tendency to variation, or, as it were, in proportion to their normal degree of plasticity. In regard to variation with latitude the modifications are apparently more general than in what I have termed longitudinal variation. In latitudinal variation the differentiation affects not merely color, but size and the details of structural parts, whereas color appears to be the main element affected by longitudinal variation. The fact of variation in size has been conceded as a general law by the majority of at least American ornithologists and mammalogists since it was so fully established by Prof. S. F. Baird in 1857 and 1858, in his admirable reports on the mammals and birds of North America, published in the series of Government Reports on the explorations and surveys of the various Pacific Railroad routes. Prof. Baird then and subsequently † called attention to the fact of the greater length of the tail in several species of birds at certain localities, and cites instances of the larger size of the bill at southern points, and the paler color of the plumage of the birds of the Plains and the arid peninsula of Lower California. All his subsequent works have furnished numerous citations of similar variation with locality, but instead of insisting upon any common tie connecting these phenomena as the result of general laws, they were viewed as evidences of specific differentiation. The differences are, indeed, so great between many of the forms now known to intergrade that it is not surprising that they were regarded as different species when known from only a few examples, apparently unconnected by intermediate forms. Subsequently, however, it has been found that they are not trenchantly separated, intermediate forms so linking them together that they can be only vaguely diagnosed. These connecting links, inhabiting — at least in the breeding season — localities intermediate in geographical position and in climatic conditions to those frequented by the more extreme forms, suggest an intimate genetic relationship and a differentiation mainly or wholly through climatic influence, or the diverse conditions of environment.

Latitudinal variation presents the following phenomena, which are of such general occurrence that even the exceptions, if such there really be, are exceedingly few.

* See Bull. Mus. Comp. Zool., vol. ii, pp. 229-247, *et seq.*, April, 1871.

† Amer. Journ. Sci. and Arts, vol. xli, 1866.

1. *As regards Size.* There is a general reduction in the size of the individual from the north southward, amounting not unfrequently to as high as ten to fifteen per cent. of the maximum size of the species. The reduction is much greater in some species, and in some groups of species, than in others, but is almost invariably considerable and easily recognizable.

2. *In respect to the Bill.* The variation of the bill is somewhat inverse to that of the general size, as a rule the southern forms having generally relatively, and often absolutely, larger bills than northern ones, the increased size taking different proportions in different species and different styles of bill. Those of a stout, thick, conical form generally increase in general size, but especially in thickness. Those of a slender, attenuate form become slenderer and relatively longer at the southward, with a decidedly greater tendency to curvature.

3. *In respect to the Claws.* A similar increase in size is apparent in the claws, especially in that of the hallux, at southern localities, perhaps less marked and less general than the increase of the bill, with which it evidently correlates.

4. *In respect to the Tail.* A marked elongation of the tail at the southward has been noticed in many cases, both in Cape St. Lucas birds (*Baird*) and in those of Florida.

5. *In respect to Color.* The differences in color are especially obvious, and may be reduced to two phases of modification:—(a) a general increase in intensity at the southward, and (b) an increase in the extent of dusky or black markings at the expense of the intervening lighter or white ones; or, conversely, the reduction in size of white spots and bars. Under the general increase in intensity the iridescence of lustrous species becomes greater, and fuscous, plumbeous, rufous, yellow and olivaceous tints are heightened in species with the color continuous in masses. Under the repression of light colors the white or yellowish edgings and spots on the wings and tail become more or less reduced, and frequently to a great degree, in species barred transversely with light and dark colors; the dark bars widen at the southward at the expense of the white or lighter ones, sometimes to such an extent as greatly to change the general aspect of the species, as is the case in the *Ortyx virginianus* of the Atlantic States, and in other well known species. Also under the tendency to the increase of dark colors, longitudinal streaks and blotches on a light ground increase in extent and intensity of color.

In respect to longitudinal variation, the differences appear to be mainly those of color, and to hold a direct relationship to the humidity of the climate. On the arid plains of the middle and western portions of the continent the annual rainfall is less than half that of the eastern half of the continent, while a rainy belt occurs on the Pacific coast, stretching northward from near the mouth of the Columbia River to Alaska, over which the annual rainfall is double that of any portion of the eastern half of the continent. Taking the species that present a nearly continental range, we find that almost invariably they pass gradually into the pallid forms of the interior at the eastern edge of the arid plains, the greatest pallor being developed in the driest regions, as the peninsula of Lower California and the almost rainless belt along the Colorado River, and northward along the eastern base of the Sierra Nevada Mountains; that on the Pacific slope they again reassume nearly the tints of the eastern form, but more to the northward, over the above-mentioned rainy region, they acquire a depth of color far in excess of what the species presents in the Atlantic region. This coincidence of bright and pale tints, with the relative humidity of the locality is certainly suggestive, if not demonstrative, of the relation of cause and effect between these two phenomena, since the same rule is traceable, over large portions, at least, of the Old World; the Scandinavian forms, for instance, being darker colored than the conspecific races of Central Europe, and these again darker than those of Northern Africa and the adjacent regions. Humidity alone, or in conjunction with greater intensity of light, seems equally well to account for the increase of color to the southward. Yet, from the well known bleaching effect of sunlight, intensified by reflection, upon the colors of animals living upon sandy islands, and sea-beaches, and desert interior regions, it seems doubtful whether the larger share of modification in intensity of color in birds may not be due to humidity alone, or to humidity and a high temperature together, rather than to intensity of light.*

In regard to the enlargement of peripheral parts at the southward, it seems not unreasonable to suppose that the increase of temperature in stimulating the circulation in these exposed members may have something to do with it, especially in view of the

* See on this point further remarks by the same writer in *Proc. Bost. Soc. Nat. Hist.* vol. xvi, June, 1874.

evidence afforded by mammals, which in general present climatic modifications parallel with those of birds.

Whatever may be the cause of the above modifications of structure and color at different localities, we certainly find the following coincidences: I. In accordance with the increase in the intensity of color in individuals of the same species from the north southward, in the northern hemisphere, the brighter colored species in genera represented in both the temperate and tropical regions occur, as a general rule, at the southward; the same fact holding good also for sub-families. In cosmopolitan genera, families, etc., the tropical species are almost always brighter colored than the extra-tropical ones. All the most gorgeously colored families of birds are either exclusively tropical or semi-tropical, with generally the outlying species more plainly colored than the average for the family. II. In accordance with the increase in the size of the bill at the southward, all the species that have this member enormously developed are tropical or semi-tropical, not only such families as have the beak at its maximum of development, as the toucans and hornbills, but in all groups in which it is unusually large, the extreme development is reached in the intertropical regions. III. In respect to the tail, with very few exceptions, all long-tailed forms attain the highest development of this member within or near the equatorial regions.

The facts indicated above, in respect to the inosculation of forms formerly regarded as specifically differentiated, will evidently require modifications of the hitherto accepted nomenclature. Evidently many of these forms are so strongly marked that they should be in some manner recognized in nomenclature, though admittedly of less than specific rank. Most naturalists now practically recognize as species such groups of individuals as are not known to graduate by nearly imperceptible stages into any other similar group; and as varieties, such groups of individuals as occur at certain localities, or over certain areas, which differ more or less from other groups inhabiting other (generally contiguous) localities, with which there is evidence that they do, more or less fully, intergrade. Convenience seems to demand such a course, in order to enable the naturalist to specify what particular variety or race of a species inhabits a given section of country—a method, in fact, already more or less generally practised.

Finally, what is the bearing of these facts of geographical va-

riation upon the question of origin of genera and species? Having approached the subject from a geographical standpoint, my own impression of the importance of the conditions of environment in modifying the characteristics of animals may have unduly impressed me; yet that they exercise a greater influence than is currently recognized I think must be admitted. How, for instance, can natural or sexual selection satisfactorily account for the occurrence of pallid forms in arid, semi-desert regions, and of brighter colored forms in contiguous humid districts, or the generally increased intensity of color southward, and its maximum development only toward and within the tropical regions? In many cases, it is true, the change in color may be protective, as it doubtless is in the assimilation of the pale tints of birds and other animals inhabiting arid plains to the generally gray color of the vegetation and the earth itself in such localities; yet, as the resemblance of the birds of these arid districts when young or in fresh plumage to those of the adjoining regions at the same season is much greater, as a general rule, than at the end of the breeding season, we have thus palpable evidence of the direct modification of color by environing conditions. Again, it is hard to see how the intenser and darker shades of the iridescence of the *Quiscalis* in the South Atlantic and Gulf States, or their slenderer and more decurved bill, or the greater breadth of the transverse black bars on the breast of the southern form of *Ortyx Virginianus* can be in the one case any more "protective," or in the other give greater facility in obtaining food, than the different colors and the differently proportioned beaks of the northern forms of these species; or of what advantage the large claws and long tails can be at southern localities rather than at northern. The variation in color is not apparently any better explained by sexual selection than are the other modifications by natural selection, for it is hardly supposable that sexual selection should act in so uniformly an accelerated degree toward the southward, or so generally from arid regions toward moister ones. On the contrary, it is just this gradual and general modification over wide areas that apparently points to climatic influence as the differentiating cause. There is, further, frequently a closer assimilation of the sexes at the southward, as among the *Icteridæ*, through the greater increased brilliancy of the female as compared with the male, which is rather

the reverse than otherwise of what is commonly supposed to be the result of sexual selection.

Freely admitting, however, that both natural selection and sexual selection are causes of modification in the gradual differentiation of animals, I am led to regard them as secondary rather than primary elements, and that climate and other environing conditions take a larger share in the work than the majority of evolutionists seem willing to admit. Evidently no single law will explain all the phases of modification by descent, and in addition to those above alluded to, doubtless what Hyatt and Cope, among American zoologists, have termed the laws of acceleration and retardation are among the other causes of the modification. In birds, even, phenomena are apparent that cannot be strictly admitted into the category of geographical or climatic variations, but seem singularly to combine some evident features of this character with a retention of a few embryonic characteristics, especially in respect to coloration, of allied intergrading forms, as occurs in some of the birds of the middle portion of the North American continent as compared with those of the eastern portion. Again, in respect to insular regions, while the above mentioned general laws of climatic variation are there evident, certain other exceptional modifications obtain, that seem specially to characterize those regions.

A word, in conclusion, respecting hybridity:—When comparatively few instances were known, in which specimens combined in various degrees the characters of two quite distinct forms, their synthetic character was generally explained by the theory of hybridity; but the irrefragability of the evidence now at hand in proof of the intergradation of such forms over large areas,—the transition being so gradual as to occupy hundreds of miles in the passage,—and also coincident with a similarly gradual change in the conditions of environment, together with the demonstrable evidence of the power of climatic influence, seems to furnish a far more satisfactory explanation of these perplexing phenomena. But an advocate of the theory of hybridity might still assume that this gradual transition over a wide area is no objection to the theory, since the gradual fading out of the impression of contact in either direction from the line of junction of the respective habitats of two forms is just the result that would be anticipated

from such a sexual intermingling of the forms in question. But the real objection to the theory—granting the possibility of hybridization on such a gigantic scale, which seems really improbable—is, that widely different forms occur also at different points in latitude, between which each successive stage of gradual differentiation can be readily traced, where hybridity can scarcely be supposed to account for the gradual change. Furthermore, gradual differentiation is now known in so many cases that it amounts to the demonstration of climatic variation as a general law, by means of which a species may be safely predicted to take on a given character under certain specific climatic conditions. If the theory of hybridity be urged to account for the intergradation of forms occurring at localities differently situated in respect to latitude, as has sometimes been done, it evidently falls under the weight it has to support; and yet there seems to be little better evidence in its behalf in cases where the intergrading forms happen to be differently situated in respect to longitude.

To describe in detail, or even to give illustrations, of geographical modification would require more space than would be proper to use in this connection, especially since a preliminary exposition of the facts upon which the preceding generalizations have been based, has already been presented in two papers in the *Bulletin of the Museum of Comparative Zoology* (Vol. ii, No. 3, April, 1871, and Vol. iii, No. 6, June, 1872).

REVIEWS AND BOOK NOTICES.

RECENT PUBLICATIONS ON ORNITHOLOGY.—Like the pages of the *NATURALIST* with which our readers are of course sufficiently familiar, recent issues of nearly all our scientific institutions show notable activity in ornithology, and a number of papers have accumulated on our table. In the Philadelphia Academy's Proceedings, Mr. Thos. G. Gentry has described peculiarities in the nidifications of *Sayornis fuscus* (1873, p. 292) and *Vireo solitarius* (*op. cit.*, 354); Mr. B. R. Hoopes has published a new variety, *Krideri*, of *Buteo borealis* (*op. cit.*, 238, pl. 5) from Iowa, a pale race of the dry interior, apparently as distinct as some others now currently recognized. In the Boston Society's Proceedings (xvi,